Chapter 4: Science

Section 1: The National Curriculum and the science strand of the Key Stage 3 National Strategy

This section focuses on:

1.1 The basic structure of the National Curriculum for science;
1.2 The aim of the Framework for teaching science: Years 7, 8 and 9;
1.3 What is involved in the section of the curriculum on Scientific enquiry (Sc1) which includes Sc1.1 Ideas and evidence and Sc1.2 Investigation skills;
1.4 The progression in knowledge and understanding from key stage 2 to key stage 3 science;
1.5 Where to find information on all aspects of teaching science.

1.1 HOW IS SCIENCE ORGANISED IN THE NATIONAL CURRICULUM?

www.qca.org.uk/qualifications/

The 1988 Education Reform Act laid out the foundations for the National Curriculum (NC), in which science became a compulsory core subject for all pupils aged 5–16. Subsequently, there have been three major revisions to the science Orders – in 1991, 1995 and 2000. The programme of study (PoS) in science is set out in four sections which relate to:

- scientific enquiry (practical science, investigations and investigative skills);
- life processes and living things (broadly, biological science);
- materials and their properties (broadly, chemical science);
- physical processes (broadly, physical science).

Each section contains sub-sections – for example, Sc3, which is '*materials and their properties*', is made up of statements on: classifying materials; changing materials; patterns of behaviour. There are separate programmes of study (PoS) for each of the four key stages (KS). The assessment requirements for KS1, KS2 and KS3 are set out in the attainment targets (ATs) related to the four sections outlined above. These are arranged in eight levels of performance, plus 'exceptional performance' which does not have a numbered level. These level descriptions used to describe a pupil's achievement in science from starting school to the end of KS3.

The Key Stage 3 National Strategy is part of the Government's commitment to raising standards in schools. The Strategy was launched in September 2001 with a focus on English and mathematics. The science strand of the Key Stage 3 National Strategy is being piloted with the intention of introducing it nationally in September 2002.

At KS4, GCSE grades (A* to G) are used to show a pupil's achievements in this qualification.

1.2 WHAT IS THE AIM OF THE FRAMEWORK FOR TEACHING SCIENCE: YEARS 7, 8 AND 9?

For more information about the science strand of the Key Stage 3 National Strategy, see

www.standards.dfes.gov.uk/keystage3/strands/?strand=science

The *Framework for teaching science: Years 7, 8 and 9* is similar to the *Frameworks* for teaching English and mathematics. It provides practical suggestions and advice on meeting the National Curriculum requirements for science. It should be read alongside the exemplar DfES/QCA publication, *Science: a scheme of work for key stage 3,* referred to here as the QCA scheme of work for science. The science *Framework* is written mainly for heads of science departments, science teachers and trainee teachers. The *Framework* is based on best practice and the experiences of pilot schools and other partners. Schools will make professional judgements about how to use it, depending on their own current ways of working and development needs. You may therefore work in schools that use the *Framework* in different ways.

The purposes of the science *Framework* are to:

- bring together in one place the experience of the pilot and best practice in secondary schools, much of which will already be familiar to teachers;
- ensure that scientific enquiry is integrated with and taught alongside knowledge and understanding in a range of contexts;
- identify the key scientific ideas that underpin science at key stage 3;
- set out yearly teaching objectives for Years 7, 8 and 9 that build on science in key stage 2 and develop pupils' understanding of the key scientific ideas in key stage 3;
- give advice on how teachers and trainee teachers can use the yearly teaching objectives to plan and teach appropriately challenging and engaging work to their pupils;
- provide a basis for target setting;
- enable headteachers and curriculum managers to set high and consistent expectations for pupils' achievement.

Optional Task

Select one of the sections in the *Framework* to help you:

	page refs.
• plan teaching of scientific enquiry;	11–13
• understand the five key ideas that underpin Key Stage 3 science;	14–22
• plan better progression into teaching;	22–30
• plan effective lessons;	37–39, 43–45
• refine your teaching methods;	41–43
• rationalise and improve assessment strategies;	49–53
• understand better the issues of inclusion, special educational needs and differentiation;	55–63
• introduce scientific vocabulary more systematically.	73–76

The *Framework* is available to read online or download from the DfES website. It is also available in paper copy (ref. 0136/2002) from DfES Publications (tel 0845 60 222 60).

The sections of the *Framework* include:

- Forward
- Introduction
- What the Strategy involves
- About this Framework
- The contents of the Framework
- Using the science Framework
- Science at key stage 3
- Raising standards in science
- Planning
- Teaching and learning strategies
- Assessment and target setting
- Inclusion and differentiation
- Related publications and websites
- Appendix 1: From key stage 2 to key stage 3
- Appendix 2:Yearly teaching objectives for scientific enquiry (Sc1)
- Appendix 3:Scientific vocabulary

The *Framework* will help teachers to teach engaging, challenging and inspiring lessons, and to establish high expectations for their pupils. It draws on the DfES/QCA scheme of work for science, and explains the ideas underlying the National Curriculum programme of study.

1.3 WHAT ARE THE REQUIREMENTS IN TERMS OF PUPILS' UNDERSTANDING OF THE NATURE OF SCIENCE AND SCIENTIFIC IDEAS?

In both the KS3 and KS4 PoS, Sc1: Scientific enquiry, is in two parts. Section 1.1 deals with *'ideas and evidence in science'*. In this section, pupils are introduced to the ways in which our scientific understanding has developed through a complex relationship between empirical questions, evidence and explanations. It is important that pupils appreciate that this process continues today at the boundary of our scientific understanding. Most of this section used to be in the introduction to each PoS in 1995 and a small but growing amount of support material can be obtained. However, the Pupil Researcher Initiatives (PRI) group at Sheffield Hallam University is currently developing KS4 materials and each awarding body will provide guidance in relation to their specifications. The British Society for the History of Science has a variety of materials.

www.bshs.org.uk

What are science investigations and how do they differ from conventional practical work?

Section 1.2 of Sc1 relates to the development of pupils' *'investigative skills'*. Broadly, practical work in school science can be categorised as either illustrative or investigative. Illustrative practical work is used to demonstrate a facet of science, and pupils are usually guided by a series of step-by-step instructions. Investigative practical work stems from pupils' statements and predictions in response to what they have seen, experienced or discussed with the teacher. Until the introduction of the NC, most practical work in secondary schools fell into the illustrative category, with comparatively little investigative work attempted. Both types of practical work are important and experience of each type will enhance a pupil's performance in the other. Through illustrative practical work, investigations and the teaching of specific investigative skills using secondary sources, pupils should develop a better understanding of science. A key aspect of the revised version of Sc1: 'Scientific enquiry' is that teaching of investigative skills should take place before and during pupils' first experience of new skills.

Assessment of these skills should take place during and after such skills are embedded and effectively taught. When pupils carry out whole investigations they have the opportunity to make use of their current knowledge of science, with the potential for exciting and sometimes innovative science. Through carrying out investigations, pupils should develop the ability to use scientific procedures to investigate a practical problem and a wider appreciation of the scientific approach. It is important that pupils use their experiences in conducting investigations to gain a better appreciation of how ideas and evidence are developed in science in general.

The essential characteristic of investigations carried out by pupils is that the responsibility for making the decisions should be with the pupils and not with you. These decisions involve designing and planning the activity, deciding on the measurements to be taken and the ways in which these will be recorded, agreeing on the best ways to present the data, evaluating the data and determining what conclusions can be drawn. Investigations are all about you deciding when to ‘let go’ and hand over to the pupils and when pupils need to be specifically taught a new investigative skill and guided in its application. However, although decisions are taken by the pupils, it is vital that you are actively involved with pupils. While pupils are carrying out investigations, you should be involved in informal teaching and assessing.

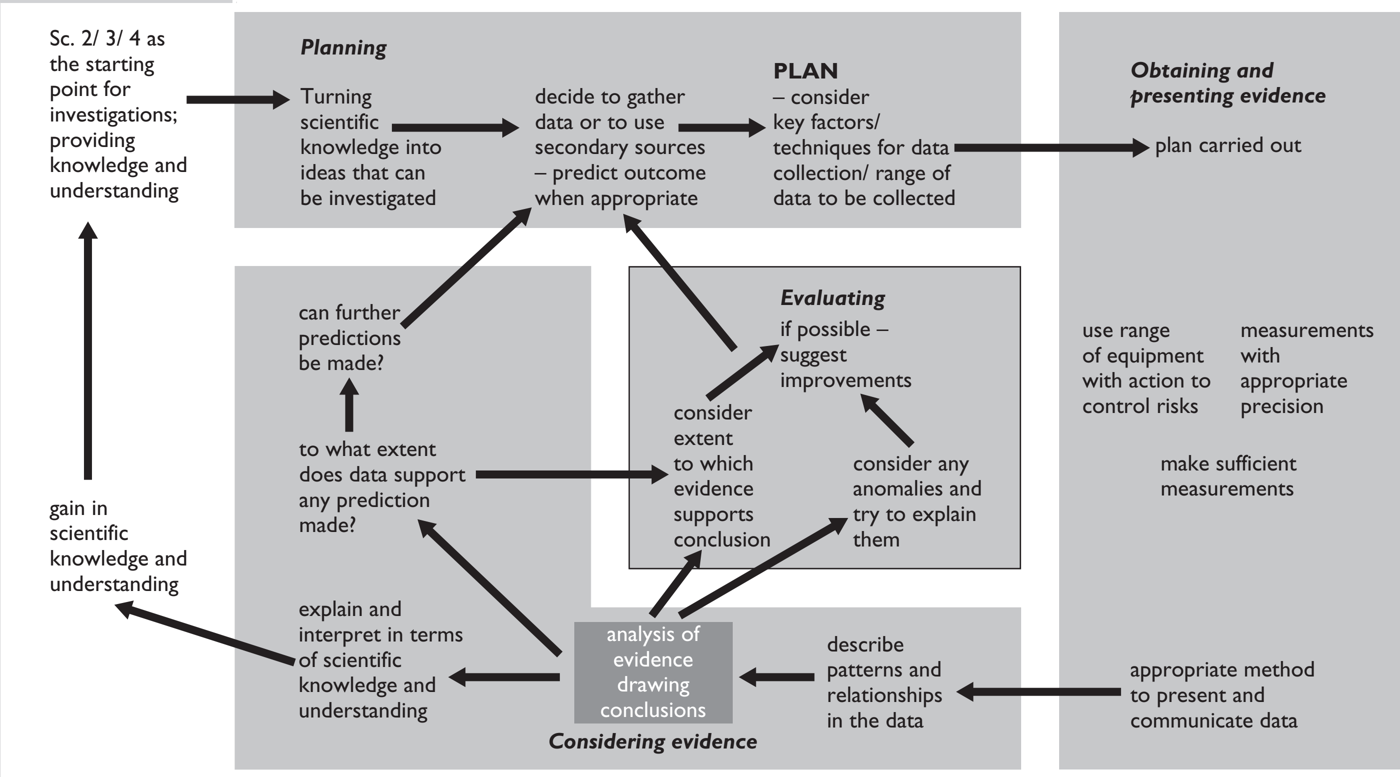

Fig. 1: Outline of Sc1.2 investigative skills – based on an original design by Northamptonshire Inspection and Advisory Service (NIAS)

Many conventional illustrative practical activities can be suitably modified and presented to pupils so that specific investigative skills can be taught or in such a way that they become ‘true’ investigations. An outline showing the relationships between the four elements of Sc1.2: Scientific enquiry is shown in Figure 1 on page 118.

1.4 WHAT IS THE IMPACT ON SECONDARY SCIENCE TEACHERS OF THE KEY STAGE 2 SCIENCE CURRICULUM?

Prior to the introduction of the NC for science, many secondary science teachers assumed that pupils entering secondary school knew no science at all. This is clearly no longer the case since all pupils entering KS3 will have studied all four sections of the PoS at both KS1 and KS2. This is six years’ study of science. Secondary science teachers now know exactly what pupils will have covered in their work in science by looking at the requirements for KS1 and KS2. In addition, since the assessment requirements of the NC tests are common to the end of KS3, secondary teachers should be able to use the KS2 NC test scores as a starting point for their work with Year 7 pupils. Although in practice the transfer might not be as smooth as suggested, a common curriculum has resulted in a much more effective transfer. If you are teaching a Year 7 group, you should be provided with information on the attainment levels for each pupil in each of the four science ATs.

1.5 WHERE DO I LOCATE IMPORTANT INFORMATION ON SCIENCE TEACHING?

www.standards.dfes.gov.uk/schemes/

Exemplar schemes of work (SoW) for KS1, KS2 and KS3, produced by the Qualifications and Curriculum Authority and the Department for Education and Skills (QCA/DfES), provide an interpretation of the PoS. These long- to medium-term planning documents can be used by teachers to produce their own or departmental short-term plans for weekly/daily lessons. The QCA/DfES SoW can be found on the DfES website.

www.ngfl.gov.uk/index.jsp

http://vtc.ngfl.gov.uk/

The government has set up a website that is intended to be the focal point for the exchange of information on resources for teachers, called the National Grid for Learning (NGfL). Within the NGfL is the Virtual Teacher Centre (VTC), which includes information on the professional development of teachers.

www.ase.org.uk

The Association for Science Education (ASE) is the most important professional organisation supporting science teaching in this country. If you are a science teacher, you should seriously consider becoming a member. Membership details are on the ASE website.

Optional Task

To help you to become familiar with the NC for science, use a copy to try to answer the following questions.

- What are PoS and ATs?
- How many ATs are there and what are they called?
- Which part of the material is appropriate for pupils aged between 11 and 14 years?
- Why are there two sets of Orders for KS4, one starting on page 37 and the other on page 46?
- Which section of the PoS includes practical work?
- Why are some words printed in grey type in the PoS?
- The breadth of study is identified in all PoS across all key stages. What does it involve at KS3 and KS4?
- How do the Orders indicate progression from KS3 and KS4 in ideas and evidence in science?
- What age range are the level descriptions aimed at, and which key stages do these represent?
- What understanding of respiration and photosynthesis is needed to satisfy the level 7 description?
- What should a pupil at level 5 be able to do in relation to graphs and what extra would be needed to reach level 6?
- What should 11–14-year-old pupils be taught about acids and bases?
- Name some of the things that pupils following double science have to be taught about the characteristics of waves that pupils following single science don't need to be taught.

Chapter 4: Section 2: Teaching science at key stage 3

This section focuses on:

2.1 What the National Curriculum (NC) requirements are at key stage 3;
2.2 How to use the DfES/QCA schemes of work;
2.3 Published resources to support teaching at this level;
2.4 How to approach updating your subject knowledge, including the use of audits;
2.5 What is required by 'ideas and evidence' in Sc1 at key stage 3;
2.6 The National Curriculum tests for key stage 3 science;
2.7 The requirements for recording and reporting key stage 3 science.

2.1 HOW IS SCIENCE AT KEY STAGE 3 ORGANISED AND TAUGHT?

At key stage 3 (KS3), schools are free to organise their science courses in any way they wish, as long as they cover the requirements set out in the National Curriculum (NC) Orders for science. You might therefore encounter a range of organisational systems. Some schools opt to teach pupils in mixed-ability groups during KS3, with a single teacher covering all the science topics. Many schools set to some degree. Teaching also varies from one teacher teaching all three sciences in Years 7 to 9, to separate teaching of biology, physics and chemistry from Year 7.

The science strand of the Key Stage 3 National Strategy aims to improve science teachers' subject knowledge, understanding and pedagogy. The training materials referred to in Section 1 and a professional development programme will be provided to support national implementation,

2.2 HOW CAN I USE THE SCHEME OF WORK FOR KEY STAGE 3?

To support science teaching at KS3, the Department for Education and Skills (DfES) and Qualifications and Curriculum Authority (QCA) have jointly produced a sample scheme of work (SoW) for KS3. This, for the first time, makes suggestions about how science teachers might approach covering the KS3 science programme of study (PoS). This is a particularly helpful document for a supply teacher since it provides a set of detailed medium-term plans for exemplar topics. It is a good guide to which topics are normally covered in each of the three years of KS3. You can download copies of the scheme from the Standards website.

www.standards.dfes.gov.uk/schemes/

2.3 WHAT PUBLISHED RESOURCES ARE AVAILABLE?

www.nc.uk.net/ld/Sc_content.html

QCA produce educational guidance for those working with pupils with learning difficulties in key stages 1 to 4, *Planning, teaching and assessing curriculum for pupils with learning difficulties: Science.* QCA also produce guidance on their website for those working with gifted and talented pupils. This includes subject guidance.

www.nc.uk.net/gt/

Identifying any commercially produced materials used in a particular school will enable you to get a useful insight into the approach to KS3 science teaching in the school.

2.4 HOW SHOULD I APPROACH AUDITING AND UPDATING MY KNOWLEDGE OF KEY STAGE 3 SCIENCE?

The best way to target the development of your subject knowledge is to carry out an audit. One way to approach this is to grade each statement in Sc2, Sc3 and Sc4 in the science NC booklet (pages 30–36) using the following scale:

1. I am aware of this material but not yet confident about my ability to teach it;
2. I feel I would be confident to teach this material to pupils.

Leave blank any statements about which you are unsure. Add a 'T' if you have taught the topic recently.

Example of an audit outline

LIFE PROCESSES AND LIVING THINGS

1. Cells and cell functions		**Audit 1**		**Audit 2**		**Audit 3**	
		1	**2**	**1**	**2**	**1**	**2**
a	that animal and plant cells can form tissues, and tissues can form organs *Note: (studied/taught/date)*						
b	the functions of chloroplasts and cell walls in plant cells and the functions of the cell membrane, cytoplasm and nucleus in both plant and animal cells *Note: (studied/taught/date)*						

There are three columns to give you the opportunity to revisit the audit from time to time, to reassess your competence and knowledge. Once this initial audit has been done, you will be in a position to target your revision. For example, you could use one of the many science revision guides that are available. However, for your weakest areas you might need to consult a textbook.

2.5 WHAT IS REQUIRED BY THE 'IDEAS AND EVIDENCE' SECTION IN SC1?

This first section of Sc1 was in the introduction to each PoS in 1995–2000 and is now section 1.1. It is intended to demonstrate to pupils that scientific knowledge is the result of human effort and comes about in a variety of ways, including the use of creative thought. These ideas are to be illustrated by exploring the ways in which scientific ideas were established in the past and by considering the ways in which current developments in science are being made.

Start by looking at the statements in the 'ideas and evidence' section in the NC. The following statements may help to provide an illustration of what is meant:

- scientists often use experiments to 'try out' their ideas;
- sometimes it is possible for scientists to come to different conclusions from the same experiment;
- sometimes new ideas in science come from the creative imagination of scientists;
- sometimes experiments are used to help to confirm that new ideas might be correct;
- sometimes experiments give unexpected results, which can result in new ideas.

What sort of investigations are done by key stage 3 pupils?

The second section of Sc1, ie. Sc1.2, is concerned with the development of pupils' investigative skills. There is a number of publications that provide ideas for investigations at KS3.

A good place to start is with the DfES KS3 SoW, discussed earlier. The four sections in Sc1.2 can be summarised as:

- planning;
- observing and collecting;
- analysing;
- evaluating.

While the overall aim is for pupils to conduct whole investigations, the development of these skills is greatly assisted by setting up tasks that only involve some of the sections discussed above – these are referred to as partial investigations. For example, you could provide pupils with a plan and ask them to carry it out, or they could be given the data from an investigation and asked to analyse and evaluate it. This approach takes less time than a full investigation, and not only allows pupils to concentrate on developing their investigative skills in particular areas but also provides the opportunity for pupils to see examples of good plans.

2.6 HOW ARE THE NATIONAL CURRICULUM TESTS IN SCIENCE AT KEY STAGE 3 ORGANISED AND WHICH PARTS OF THE NC DO THEY ADDRESS?

Since science is a core subject, not only is it a compulsory subject for all pupils in all four key stages, but it is part of the end of key stage testing process. All pupils are expected to take a science test at the end of KS2 and KS3. Tests in English and mathematics are also required at the end of KS1, KS2 and KS3.

www.standards.dfee.gov.uk

There are four attainment targets (ATs) for each PoS in science, each of which provides descriptions to identify levels of attainment. The KS3 tests are intended to identify a pupil's level of working for all four sections of the science PoS. These tests are in the form of written papers. Schools decide for the majority of pupils whether they take papers aimed at pupils working between levels 3 and 6 or levels 5 and 7. There are also separate tasks aimed a pupils working at levels 1 and 2 and an optional extension paper for pupils working towards level 8 or 'exceptional performance'. This pattern of assessment is likely to change in 2003.

QCA: tel: 01787 884444 or e-mail QCA@prologistics.co.uk

www.testbase.co.uk

The KS3 test papers provide an effective means of evaluating your personal subject knowledge, and the Teacher Pack includes a helpful mark scheme (contact the QCA publications department). A particularly useful resource to use is the *Test Base* CD-ROM produced by QCA. It contains all the KS1, 2 and 3 NC test material, which includes all the science test questions for the last six years.

2.7 WHAT ARE THE STATUTORY REPORTING REQUIREMENTS FOR SCIENCE AT KEY STAGE 3?

At the end of KS3, schools are expected to report to parents on the level attained by their children in the external tests. However, all teachers must identify a level in relation to school-based work for all pupils, for each of the four ATs. Sc1 has been assessed by NC tests since 2001. Normally, only an average (to a whole number) of these four levels is given to parents. Nevertheless, teachers are expected to keep records of all four levels and update their records at least once a year.

Chapter 4: Section 3: Teaching science at key stage 4

This section focuses on:

3.1 The organisation of key stage 4 science;
3.2 The expectations of a teacher's subject knowledge;
3.3 The assessment requirements for GCSE science.

3.1 HOW IS SCIENCE ORGANISED AT KEY STAGE 4?

www.qca.org.uk/menu.htm

www.aqa.org.uk/

www.edexcel.org.uk

www.meg.org.uk

At key stage 4, (KS4) the National Curriculum (NC) programme of study (PoS) is the template for GCSE qualifications. Each awarding body produces GCSE specifications (what we used to call syllabuses). These specifications are required to conform to the NC and so schools rarely use the NC document itself at KS4. The old examination boards have been amalgamated into three awarding bodies:

Assessment and Qualifications Alliance	• AQA – made up of AEB/SEG, City and Guilds and NEAB.
Edexcel Foundation	• Made up of BTEC and ULEAC.
Oxford, Cambridge, and RSA	• OCR – made up of MEG and OCEAC.

This means that each awarding body produces not only GCSE and GCE Advanced specifications, but also specifications for vocational qualifications such as GNVQ.

At KS4 (GCSE), the NC allows for two alternative science courses:

- Double Award Science, which is equivalent to two GCSE subjects;
- Single Award Science, which is equivalent to one GCSE.

Schools are also allowed to offer the three separate sciences, with the restriction that these pupils must take all three (Triple Award).

There is a number of ways of organising the science content, including:

- **Modular science (single or double award)**
  Science work is organised into topics, which may be constituted in a number of possible ways, eg. each topic from one specific area of science, or thematically, containing several areas of science;
- **Co-ordinated science (usually only double award)**
  Refers to a course made up from the three separate sciences. The course is organised so that a common approach is used and links between the subjects are highlighted;
- **Other science courses (single or double award)**
  Some courses are assessment-led (for example, OCR Double Award B: Staged assessment), in which pupils receive regular feedback on their performance throughout the course. *Salters Science* (also from OCR) is an example of an applications-led course.

3.2 WILL I BE EXPECTED TO TEACH OUTSIDE MY SUBJECT SPECIALISM?

School science departments are organised in a wide variety of ways, ranging from three entirely separate departments for biology, chemistry and physics, to a completely integrated approach. The most common approach is that science teachers are expected to teach all three science subjects at KS3 and either teach just their specialist subject at KS4, or share the teaching of all three sciences with one other teacher. For example, a biologist and physicist could share the chemistry teaching. Therefore you should aim to become proficient in at least one subject outside your specialism at KS4.

How do I go about updating my knowledge of key stage 4 science?

There is plenty of material to support pupils with their work at GCSE level and much of this can be used by adults to learn or revise science topics. A number of revision guides are identified in 'Useful reading and resources' at the end of the chapter. The BBC Bitesize website has some excellent revision materials. There are also CD-ROM-based resources which have exam questions, sample answers and examiners' comments on the performance of pupils.

www.bbc.co.uk/schools/gcsebitesize/

3.3 HOW DO I ASSESS PRACTICAL WORK IN GCSE SCIENCE?

External written papers will constitute 75–80 per cent of the final mark, although some of this can be via modular tests before the final examinations. The remaining 20–25 per cent is obtained from teacher assessment of pupils' investigation skills as set out in Sc1.2. The criteria used for this assessment are identical for all science specifications. You will be required to assess four skill areas:

- planning (P);
- obtaining and presenting evidence (O);
- analysing and considering evidence (A);
- evaluating (E).

For each of these skill areas, mark descriptions are used with areas (P) (O) and (A) on a 0–8 scale and area (E) on a 0–6 scale.

There are rules about the context of the investigations in relation to Sc2, Sc3 and Sc4 and the marks derived from partial and whole investigations. You will have to collect evidence, usually in the form of pupils' written reports, to support your assessment and these are usually moderated internally and externally by the examination board. It is important that you are aware of the criteria for each skill area. You will need to give pupils opportunities to develop their investigative skills and to be aware of the criteria that they are expected to meet. However, you must not provide guidance to pupils on how to conduct their formal investigations. With the time constraints on GCSE science teaching, it is difficult to find the balance between providing pupils with enough opportunities to learn the investigative skills required and to assess accurately their ability to conduct investigations for themselves.

Chapter 4: Section 4: Post-16 science courses

This section focuses on:

4.1 The structure and organisation of A level science, including AS and A2 courses;
4.2 The requirements for Advanced Vocational Certificate of Education (AVCE), previously known as GNVQ Advanced;
4.3 The introduction of Key Skills in post-16 courses.

4.1 HOW IS A LEVEL SCIENCE ORGANISED, TAUGHT AND ASSESSED?

www.qca.org.uk/menu.htm

www.aqa.org.uk/

www.edexcel.org.uk

www.ocr.org.uk

Advanced science courses now consist of two elements. Year 1 is known as AS (Advanced Subsidiary) and is a free-standing course so that students will be able to complete the year's course and gain an AS level award. The AS course is pitched between the current standards for GCSE and A level. Students can then continue, if they wish, to Year 2, which is known as A2 and is at full A level standard. If students complete the A2 course successfully , then they will have achieved an A level qualification in that subject. One of the reasons for the change is to try to increase the number of subjects studied in Year 12 (lower-sixth form) and try to reduce, to some extent, early specialisation.

One consequence of the change to AS and A2 is that from September 2000 the specifications for all A level courses were revised. In some cases, this provided the opportunity for innovative new courses to be designed – for example, the new *Advancing Physics* course from OCR and the *Salters Advanced Physics* course from Edexcel.

AS courses are deemed to be equivalent to half a full A level course, and so are allocated half the UCAS tariff for university entry, ie. grade 'A', worth ten points for a full A level, is worth five points at AS level.

4.2 WHAT IS THE DIFFERENCE BETWEEN THE ADVANCED VOCATIONAL CERTIFICATE OF EDUCATION (AVCE) SCIENCE AND A LEVEL SCIENCE?

The AVCE (Advanced Vocational Certificate of Education) or Vocational A level has replaced the GNVQ (General National Vocational Qualification).

www.qca.org.uk/qualifications

The vocational A level is offered as a science course only, rather than the separate sciences mainly on offer for the academic A level courses. 'Science' and 'Environmental Science' are both offered at AS/A2. 'Science for Public Understanding' is offered at AS only.

However, the more significant differences lie in the background philosophy of the vocational approach. The aim is to develop knowledge, skills and understanding through experiencing the types of activity undertaken by scientists. Therefore, the initial approach is to consider science in terms of industrial and research applications. Consequently, teachers who have had some kind of industrial or research background, could initially be more comfortable with this approach than those from a more academic background.

The style of teaching is usually less formal than for the academic A level, and students are expected to be much more active in researching topics and in presenting reports. Vocational A levels are available in units equivalent to a full A level or two full A level courses. There is a greater emphasis on internal assessment with a minimum of 30 per cent assessed externally.

4.3 WHAT ARE THE KEY SKILLS AND HOW ARE THEY RELATED TO ADVANCED SCIENCE COURSES?

Key skills are the skills needed to succeed in education and everyday life. There are six key skills:

Three ‘generic’ key skills:

- Communication;
- Application of number;
- Information technology.

Three ‘further’ key skills:

- Working with others;
- Improving your own learning and performance;
- Problem-solving.

Key skills were originally introduced into GNVQ courses since these are the skills that are particularly prized by employers. However, all students doing post-16 courses will have the opportunity to work towards a key skills qualification (currently relating to the three ‘generic’ key skills only). Students are required to compile a portfolio of work during their studies which can be assessed against a set of key skills criteria, and to sit an external examination.

There are key skills criteria at three levels – the most significant in this context are level 2 (broadly GCSE standard) and level 3 (Advanced level standard). The latest subject specifications at Advanced level indicate where in the course students might assemble evidence for their key skills portfolios. This approach is still very new and teachers are struggling to find ways of modifying current AS and A2 activities, so that they also provide evidence for the key skills criteria.

Chapter 4: Section 5: Planning, teaching and assessment

This section focuses on:

5.1 Key elements of lesson planning;
5.2 Active use of text in science teaching;
5.3 How science teaching can contribute to literacy and numeracy;
5.4 Assessing pupils' understanding in science;
5.5 What is meant by target setting;
5.6 What records you are expected to keep;
5.7 The requirements for sex education in the science curriculum.

5.1 WHAT ARE THE KEY ELEMENTS IN A LESSON PLAN?

There is a real danger of approaching a lesson simply in terms of a range of activities that will occupy and interest the pupils, particularly when you only have a short period of contact with the class. The more productive and effective starting point in terms of pupils' learning is to identify clearly, and in as much detail as possible, the specific learning objectives for the lesson.

To do this effectively you will need to know how the lesson fits into the scheme of work (SoW) for the topic, and especially what was covered in the previous lesson. The structure of the lesson should then be directed to achieving these objectives. It is also vital to convey to the pupils what they are expected to learn. In some cases, it may be appropriate to do this by writing the objectives on the board at the start of the lesson and referring to them during the lesson. Preparation is especially important in science teaching since, often, equipment is required in addition to the range of resources used in other subject areas.

At the planning stage it is vital to consider how the activities are going to provide you with feedback on how well the pupils are achieving the learning objectives. This is likely to be through informal means such as question and answer sessions with individuals or the whole class. Particularly important is the careful monitoring of pupils' work during tasks, as opposed to superficial monitoring making sure everyone is on task. Useful insights into understanding can be obtained by directing questions to individuals, setting tasks that require application of knowledge and the analysis of information, and by asking pupils to present their ideas to the rest of the group. Homework is the most obvious way to get information on performance, but it is vital to identify clear success criteria with pupils, so that they know exactly what is required of them. The planning format overleaf includes the features identified above. It is used at North Walsham High School and it has been slightly 'customised' for science by adding 'Equipment and Risk assessment'.

Example lesson planning sheet

Lesson Planning Sheet

Dept:	Date:	Module Title:	Group:	Teacher:
Subject:	Lesson: of	Topic:	Topic:	Ability:

Skills, knowledge and understanding LEARNING OUTCOMES DIFFERENTIATION TARGET LEVELS	TIMINGS	Assessment Opportunities ACTIVITIES RESOURCES	EVALUATION/ACTION POINTS
•		Registration/introduction/explanation.	
•			
•			EQUIPMENT
KEY WORDS for this lesson			
Opportunities to extend: Literacy:			RISK ASSESSMENT
Numeracy:			
ICT:			Homework:
Spiritual, Moral, Cultural, Social, Development:	5 minutes	Recap/review of the learning activities.	Due date:

The lesson plan must be complete and visually accessible from the beginning of the lesson.

5.2 HOW SHOULD I USE TEXT IN SCIENCE TEACHING?

Practical work in science has a very high status and profile. While there are many positive aspects to pupils conducting practical activities as part of their science education, there is a danger that practical work is sometime undertaken simply because it is the thing to do.

'Practical work can be used to create the illusion of active and purposeful learning.' (Osborne, 1993, p18)

'… students need to spend more time interacting with ideas and less time interacting with apparatus.' (Gunstone, 1991, p74)

Obviously, there is a number of difficulties in conducting practical work in an unfamiliar laboratory and at short notice. So what are the alternatives, bearing in mind the aim of achieving the learning objectives?

One approach is to make use of text by what is described as 'active reading'. Learning from text requires a fundamentally different type of reading from that used for normal reading. Normal reading, where the eye absorbs information in a continuous flow, is a receptive, passive and usually solitary activity. For learning, reading needs to be reflective and for a purpose, requiring the reader to break, reread and reflect. This is best done via group work.

Reconstruction DARTs

One approach is to use DARTs (Directed Activity Related to Text). There are two main types of DART:

- where the original text is modified before use so, in effect, it becomes a problem-solving exercise (fill in missing words/reorder into correct sequence/add missing labels);
- unmodified text is used and the teacher identifies targets for the pupils. This often involves pupils marking the text in some way.

As a supply teacher, it would be a sensible idea for you to build up an array of DARTs on different topics. The 'Useful reading and resources' section at the end of the chapter provides a number of ideas.

The simplest form of reconstruction DART is the cloze exercise, which is widely used by many teachers. This involves removing part of the text from a passage and asking the pupils to fill in the missing words. Less common are activities that involve reordering text. This is a useful exercise when pupils are learning about a sequence of events or a process – for example, the life cycle of stars. However, instructions for a practical activity can be given in this way, so that pupils need to identify the correct sequence before starting the activity. One of the advantages of this approach is that it encourages pupils to read the instructions and also staggers the collection of equipment, since they complete the task at different times.

Analysis DARTs

Analysis DARTs are less common but are equally effective when learning about structure or a sequence of events – the relevant text could be marked and used to label a diagram. An alternative is to ask pupils to construct a table of information by extracting and ordering data from text. An example from the book by Davies and Greene (1984, p17) is to use a section of text about tooth structure to construct the following table:

Name of part	Location	Property	Function

Davies argues that tables of this form can be used for a large number of science texts. Articles by Osborne and Wellington suggest other ideas on how texts, including newspaper articles, can be used to encourage pupils to engage actively with ideas about science.

5.3 HOW CAN SCIENCE TEACHING CONTRIBUTE TO LITERACY AND NUMERACY DEVELOPMENT?

The National Curriculum (NC) for science includes cross-references to the English, mathematics and information and communication technology (ICT) curricula. This is done for two main reasons. Firstly, developing pupils' skills in these areas will result in them being in a better position to learn the science you are trying to teach them. Secondly, every subject area has a responsibility to contribute to the development of these core skills. The Key Stage 3 National Strategy has developed training materials to support professional development of teachers in planning and teaching numeracy and literacy across the curriculum. These materials are available on the DfES website.

www.standards.dfee.gov.uk/numeracy/

Clearly mathematics is a central part of science education. The problems start to arise when science teachers adopt an approach to mathematics that is not consistent with the approach taken by mathematics teachers themselves. For example, it is standard practice not only to encourage pupils to solve mathematical problems using their own algorithms, but to encourage pupils to share their methods. Problems arise therefore when science teachers tell pupils they must adopt a particular approach, particularly when this is not a method used in current mathematics teaching. Consequently, it is important for you as a science teacher to be aware of the statements in the mathematics NC that link to science. More important still is the need to discuss with mathematics teachers the approach they take to teaching these topics and the sequence in which they are covered in the mathematics curriculum.

www.standards.dfes.gov.uk/keystage3/publications/ – scroll down to the bottom of the page and access the publications under 'cross-curricular' tab.

Written communication is a vital tool for the development of scientific knowledge, and you should take every opportunity to use it to help pupils to develop their knowledge and understanding of science. Too often the pupils' only experience of writing in science lessons is when they are asked to write reports of experiments, for which they often need to use a very formal writing style.

You can use the development of literacy skills as a means of improving pupils' scientific understanding. To achieve this it is important to encourage pupils to write for a range of purposes and for different audiences. By expanding the range of styles you include in science teaching, you are likely to use writing as a means of enabling pupils to express their scientific understanding and perhaps to motivate some pupils who see science as dull and unimaginative.

Examples of tasks that aim to do this are:

- imagine you are a … – now write about your experiences;
- describe what it would be like if you were the same size as a …;
- write a letter to a newspaper arguing the case for or against …;
- write about a day in the life of …;
- write a poem about ….

For more information, see Chapter 2: English in this book

The blank page can be very intimidating for pupils who are not confident writers and therefore writing frames with specific sentence starter prompts can be helpful. The use of collaborative writing and word processors for drafting and re-drafting can also encourage pupils to express their ideas and understanding in words.

5.4 HOW DO I ASSESS PUPILS' UNDERSTANDING IN SCIENCE?

Perhaps the biggest changes to teaching and learning have occurred in relation to the assessment of pupils. This started when the first NC for science, in 1988, specified a very large number of specific criteria for science teachers to assess. This started the move away from a norm-based assessment, which involves giving marks that have no specific meaning other than to provide a position relative to others in the group. The criterion reference system, which is the basis of National Curriculum tests and GCSE examinations, is intended to give a grade that is specific to an identified level of performance. This is done by publishing precise criteria related to each level of performance.

The important message here is that, wherever possible, you should aim to provide pupils with particular success criteria for the tasks set. This then enables you to impart to pupils exactly what they did and did not achieve. Feedback to pupils can take a range of forms, but identifying what they have achieved and what the next target should be are likely to be much more helpful than simply giving a mark out of ten.

During key stage 3 (KS3), assessing class work using the NC levels can be done by using the system employed in the National Curriculum tests.

Each question is judged to represent a particular level and so the overall performance can be translated into a level description. Some science departments use this system for end of topic tests, but there is no reason why it cannot be used for routine homework questions. Caution is needed when using this approach because the level descriptions are intended for end-of-key stage comment and therefore it is sensible not to disclose levels to pupils too often since they are unlikely to see much change over a relatively long period of time.

5.5 HOW DO I SUPPORT PUPILS BY IDENTIFYING INDIVIDUAL TARGETS FOR THEM?

As indicated in section 5.4, you should try to give feedback to pupils that helps them to identify the next steps in their learning. Encouraging pupils to take responsibility for their own learning is the ideal. Over the past few years, a number of schools has been exploring ways of using targets to improve pupils' performance across the curriculum. As an individual teacher, particularly one who may only have limited contact with a class, encouraging pupils to set their own targets, in discussion with you, can be a useful start. It is probably best to concentrate on short-term achievable targets, which could be as simple as improving the presentation of work or handing in homework on time.

www.standards.dfee.gov.uk/performance/

At a whole-school level, there have been a number of initiatives that make use of NC test data or use diagnostic tests to help schools to make predictions and to assess overall performance.

5.6 WHAT RECORDS AM I EXPECTED TO KEEP?

The introduction of the NC and the statutory reporting requirements have resulted in the need for all teachers to keep up-to-date and accurate records of pupils' performance. Schools are required to keep records on every pupil, including information on academic achievement, other skills and abilities and progress made in school. Records must be updated at least once a year. There are no requirements about how, or in what form records should be kept. Decisions about how to mark work and record progress are professional matters for schools. As a supply teacher it is important that you obtain the school's/department's marking and record-keeping policies. You will also need to find out what the department's policy is on retention of evidence of pupil progress. Although it is not a statutory requirement, many schools now expect teachers to record a level for their pupils at the end of each year, some do so termly and others half-termly.

Sc1 investigations are more easily graded in terms of NC levels, but you are expected to monitor and record the attainment level for Sc2, Sc3 and Sc4 as well. When taking over a KS3 class, you should be given information on the level at which each pupil is working. You should aim to update this information with the results of the work you set, and be able to pass this information on to the next teacher.

At KS4, the main recording requirement is in relation to the assessment of pupils' investigative skills. Since it is only at the end of the second term in Year 11 that a science department will be able to decide which pieces of coursework will be used, it is vital that you keep accurate and complete records of pupils' performance for each assessment area (P, O, A and E). Most schools have a recording pro forma for this. In addition, since sample material will be sent to the exam board, it is important that you annotate these scripts wherever possible when marking them, so that others will be able to understand the reasons for the marks you have given.

5.7 HOW AM I EXPECTED TO APPROACH SEX EDUCATION WITHIN THE SCIENCE CURRICULUM?

Sex education within the NC for science is limited to sexual reproduction. It must be taught to all pupils and parents cannot withdraw their children from such lessons. Schools are also required to provide a sex and relationships education programme. This includes physical, moral and emotional development, sexual health and sexuality. Parents do have the right to withdraw their children from this programme.

You must ensure that you adhere to the guidelines regarding the content and delivery of sex education in your science lessons. It is therefore very important that you seek guidance from your head of department and refer to the school policy on sex and relationships education.

For more information, see Useful reading and resources for this chapter

Help and information can be found in the resources listed at the end of this chapter. The DfEE *Sex and relationship education guidance* document (July 2000) is particularly useful.

Chapter 4: Section 6: Teaching science to pupils with Special Educational Needs (SEN)

This section focuses on:

6.1 Teaching science to pupils with Special Educational Needs (SEN);
6.2 The role of in-class learning support assistants (LSA);
6.3 Practical work with pupils who are physically disadvantaged.

6.1 HOW CAN I SUPPORT PUPILS WITH SPECIAL EDUCATIONAL NEEDS?

www.qca.org.uk/ca/inclusion/

www.becta.org.uk/inclusion/index.html

For more information, see 'Getting Started' and 'Classroom and Behaviour Management' in this series

There is now a strong 'inclusion' movement in schools so you are likely to teach more pupils who have some form of special need. The nature of laboratory work means that extra consideration needs to be made for these pupils. The website and references indicated in this section will provide you with useful background material, but there is no substitute for practical advice from experienced staff in school. You need to be aware of the five stages in the 'statementing' process so that you can interpret what it means to have a pupil in your group.

Approaches and resources

Talk to the Special Educational Needs Co-ordinator (SENCO) about the general approach taken and about individual pupils whom you teach. The SENCO will be able to advise you on matters such as worksheet layout or whether a pupil needs specific aids, such as coloured overlays on text.

6.2 HOW SHOULD I WORK WITH LEARNING SUPPORT ASSISTANTS (LSAs)?

You should be given information about any pupils with SEN. Some pupils might have an learning support assistant (LSA) to provide in-class support. For this system to operate effectively, you will need to work as a team, which means briefing the LSA on the learning objectives and discussing your approach to the lesson. It is also important to remember that although a pupil might have someone to support their learning, they will still need regular contact with the class teacher. The school or the science department might have produced guidelines on working with LSAs.

6.3 HOW DO I SUPPORT PUPILS WHO ARE PHYSICALLY DISADVANTAGED?

You could teach pupils who have some kind of physical disadvantage. Before meeting the class, the head of department should brief you about the department's approach. You may find that a laboratory or some of the equipment has been specially adapted to support the pupil when carrying out practical work.

Chapter 4: Section 7:
Health and safety in school science

This section focuses on:

7.1 The legal requirements related to science teaching;
7.2 The meaning of risk assessment in the context of school science;
7.3 Important safety considerations when organising and running practical activities in the school laboratory;
7.4 How to locate important and relevant publications.

7.1 WHAT ARE THE LEGAL DUTIES AND RESPONSIBILITIES OF A SCIENCE TEACHER?

www.ase.org.uk/

You are liable for the consequences of an accident to a pupil in your charge only if it is established that you have been negligent in your duty. You must, therefore, take all reasonable precautions in the conduct of your work and you must ask pupils to undertake only those practical activities that are reasonable in the light of their experience, ability and age.

Your responsibilities as a science teacher include:

- complying with the guidelines laid down by the employer;
- adhering to the recommended health and safety practices and procedures, including consulting the employer's appropriate model risk assessments;
- reporting any deficiencies and defects in administering the procedures.

7.2 WHERE WILL I FIND RISK ASSESSMENT INFORMATION AND HOW DO I USE IT?

www.cleapss.org.uk

www.sserc.org.uk

Science teachers are required to consult a risk assessment on the practical activities they conduct. Therefore, you must always identify the model risk assessment for any activity you use in the classroom and always abide by what it stipulates. In most cases, risk assessments are identified in schemes of work (SoW) or in teacher's notes for specific lessons with, if necessary, references to further appropriate written information. There is often safety information included on worksheets for practical activities. It is your responsibility, as the class teacher, to obtain any risk assessment and to follow the advice or instructions given, otherwise you can be said to have been negligent.

7.3 WHAT SAFETY ISSUES MUST I CONSIDER?

Before conducting practical work of any kind in a school laboratory, you must be sure that you can do so safely. Below is a checklist that you could use as a starting point.

- If you are at all unsure, do not go ahead. Discuss any concerns with a member of the science department.
- Are you aware of the model risk assessments for the science activities that you are about to conduct (both demonstrations and class practicals) and are you following the advice given?
- Are appropriate safety notes included in your lesson plans?
- Have you tried out the activity, making notes of points to bring to the attention of pupils?
- How do you intend to bring safety issues to the attention of pupils?
- Are you setting a good example to pupils on safety – for example, wearing eye protection yourself if you ask pupils to do so?
- Do you know how to deal with an emergency?

What are the key considerations when I start to teach in an unknown laboratory?

It could be unsafe to conduct a practical activity in a laboratory in which you have not taught before. The following questions, related to safety preparations, should show you why this is the case.

- Have you read a copy of the science department's health and safety policy for staff?
- Do you know what the school's first-aid procedures are?
- In each room in which you teach, do you know the location of:
  - gas shut-off valve?
  - electricity trip-switch?
  - the nearest first-aider?
  - eye-wash facilities?
  - spills kit?
  - water stop-cock?
  - fire extinguishers?

7.4 WHERE CAN I FIND OUT MORE?

For more information, see Useful reading and resources for this chapter

For a fuller checklist, see Appendix C in *Safe and exciting science* from the Association for Science Education publications (ASE, 1999). This booklet also identifies and discusses a number of scenarios related to practical safety issues.

Chapter 4: Section 8: Some examples of research evidence into science teaching

This section focuses on:

8.1 The Cognitive Acceleration through Science Education project;
8.2 'Thinking Science';
8.3 The Children's Learning in Science project;
8.4 The location of inspection evidence on science teaching.

Why should science teachers bother with research evidence?

The debate about the relative merits of theory and practice is still a live issue today. For example, is it important for trainee teachers to consider educational theory or can they get all they need by working alongside an experienced practitioner? The answer depends on the extent to which the theory can inform classroom practice. Science education is fortunate in that there has been a number of large-scale research projects which have direct relevance to everyday science teaching. This section will introduce you to two of these projects.

8.1 WHAT IS COGNITIVE ACCELERATION THROUGH SCIENCE EDUCATION (CASE) AND WHY IS THERE SO MUCH CURRENT INTEREST IN IT?

The Cognitive Acceleration through Science Education (CASE) project has been in operation for over a decade now, and has recently gained a much higher profile. The work is based around the ideas of the psychologist Piaget. He considered that as children develop, their cognitive abilities go through a number of age-related stages.

In the context of secondary science education, the most significant development is from the 'concrete' stage to the 'formal thinking' stage. In outline, the features of concrete thinking are the ability only to be able to cope with a limited number of variables and an ability to describe but not to explain situations. Features of formal thinking include the capability to cope with multi-variable problems and to provide explanations for events.

The results of large-scale testing of pupils' cognitive abilities indicated that only 28 per cent of 14-year-olds were able to demonstrate some evidence of formal thinking, and a large proportion of pupils never even reach this stage. When the requirements of the science National Curriculum (NC) are analysed, it is evident that most of the requirements above level 5 require formal thinking. Therefore, careful lesson planning is required if pupils are to access the material.

8.2 WHAT ARE THE IDEAS BEHIND THE 'THINKING SCIENCE' LESSONS?

Michael Shayer and Philip Adey created an intervention programme designed to accelerate pupils' cognitive development during key stage 3 (KS3), in order to make them better able to learn the KS4 curriculum. The approach was based on the ideas of 'cognitive conflict' from Piaget and 'social constructivism' from a Russian psychologist called Lev Vygotsky.

It is not possible to explain the detail of the approach here, but Shayer and Adey produced a series of activities that are designed to stimulate the cognitive development of pupils. This involves a two-year programme for pupils in Years 7 and 8. Once every two weeks a conventional science lesson is replaced by an activity from the *Thinking Science* pack. It is important to point out that the aim is not to teach science in these lessons, but to use the context of science-related activities to develop pupils' thinking skills. Therefore, it is vital for the effective implementation of this intervention strategy that the teachers involved have been fully trained and understand the psychology behind the approach. A third edition of the *Thinking Science* material, published in August 2001 (Adey, Shayer & Yates), includes CD-ROM-based resources.

Once pupils have completed the programme in Years 7 and 8, there is no additional intervention. However, the evidence from the researchers involved in the CASE project would suggest spectacular improvements in pupils' GCSE grades, not only in science but also in mathematics and, perhaps most surprising of all, in English.

It is essential to finish with a word of caution. If you teach in a school that is using the *Thinking Science* materials, unless you have had the appropriate training, you will not be able to walk into a classroom and run a *Thinking Science* lesson effectively.

8.3 HOW CAN I USE LESSONS FROM THE CHILDREN'S LEARNING IN SCIENCE (CLIS) PROJECT IN MY SCIENCE TEACHING?

The other large-scale research project related to the teaching of science is the Children's Learning in Science (CLIS) project, which ran for about a decade from the mid-1980s. This project was based on the constructivist view of learning in saying that the learner actively constructs their own understanding from their interaction with the outside world, rather than being the passive recipient of others' knowledge. One of the important consequences of this is that learning is a continuous process and so pupils arrive at your lessons with pre-conceived ideas about the world around them. The CLIS project was able to identify many of these 'naïve' ideas and to show that common misconceptions are expressed by children from all parts of the world.

These ideas were incorporated into an approach to teaching that started with the premise that teaching must begin from the current ideas of the pupil and not to treat them as 'empty vessels'. This was expressed very effectively by the director of the project, Ros Driver, who used the analogy that if you wished to give directions over the phone your first question should be 'where are you now?' (Driver, 1994, p42).

For more information, see Useful reading and resources for this chapter

The first step in this teaching approach, called 'elicitation', provides the opportunity for the pupils to make their own ideas explicit and to listen to the ideas of others. The argument is that only by articulating their own ideas will they be in a position to change their understanding in response to teaching. The other stages involve exposing pupils to the scientific view and providing opportunities for pupils to apply their existing knowledge. The evidence from the project is that, even with this approach, it is very difficult to change pupils' earlier ideas.

The main messages for everyday teaching are that you should become aware of the typical misconceptions you are likely to meet (see *Making Sense of Secondary Science*, Driver et al, 1994), and that each topic should start by eliciting pupils' existing ideas.

8.4 HOW CAN I LOCATE INSPECTION EVIDENCE ON SCIENCE TEACHING?

In addition to research data providing important information about how to make science teaching more effective, there is also the evidence that is produced as part of the inspection process. Each year, Her Majesty's Chief Inspector of Schools publishes a report which includes reference to the overall performance of science education. Periodically, there are summaries of inspection findings, representing several years of inspection evidence. This information is available on the inspections website.

www.ofsted.gov.uk/about/index.htm

www.becta.org.uk/inspection

Chapter 4: Section 9: ICT and science

This section focuses on:

9.1 WHAT IS NOF TRAINING?

For more information, see Chapter 3: ICT in 'Filling the Gaps' in this series

Computers have been used in secondary science education for many years, but it is only in the past five years or so that they have had such a high profile. Part of this change has been the developing importance of the internet as a means of communicating via the World Wide Web and by e-mail. Part of the rising profile of information and communication technology (ICT) has been its increasing prominence in the National Curriculum (NC) for all subjects. Teachers have no option but to make use of ICT to support their teaching. However, it is also vital that you, as a science teacher, are able to identify when it is relevant to use ICT and how to make the most of this potentially powerful teaching aid.

www.canteach.gov.uk/community/ict/nof/nof.htm

www.nof.org.uk/

Currently every teacher in England is expected to undergo training in the use of ICT in the classroom. This INSET is known as NOF training, since it is funded by the National Lottery New Opportunities Fund. The outcome of this training is identified by a series of statements in two categories, 'Effective teaching and assessment methods' and 'Teachers' knowledge and understanding of, and competence with, ICT.'

How do I go about developing my ICT skills for the classroom?

The first stage, which is similar to the development of your subject knowledge in science discussed earlier, is to audit your current ICT skills against the requirements set out in the expected outcomes of the NOF training. However, it is important not to wait until you have highly developed personal skills with ICT before using it in the classroom. Start by including ICT as a small element in your lessons, perhaps by demonstrating a simulation program.

www.becta.org.uk/index.cfm

The Becta website www.ictadvice.gov.uk offers a wealth of support to teachers

There is considerable support available to you for developing your use of ICT in the classroom. For all issues relating to the use of ICT in education, consult the website of the British Educational Communications and Technology Agency (Becta).

9.2 WHICH ICT APPLICATIONS ARE PARTICULARLY RELEVANT TO SCIENCE?

See Useful reading and resources for this chapter

Since practical work is at the heart of science education in this country, making use of computers to assist in this process, often called data logging, is probably the most important ICT application. It involves using sensors to monitor physical quantities such as temperature, light and pH and for this data to be passed via a data logger, to be presented on a computer screen (often in the form of a graph).

The use of computer simulations means that you can extend what is possible via hands-on practical work to include difficult, dangerous or time-consuming experiments. A potent combination is the use of a data logger followed by a simulation – for example, an experiment on rates of reaction followed by a simulation which allows the investigation of a much wider range of variables than is possible when using only a hands-on approach.

http://curriculum.becta.org.uk/docserver.php?temid=98

http://vtc.ngfl.gov.uk/docserver.php?temid=77

http://vtc.ngfl.gov.uk/docserver.php?temid=208

You are no longer limited to the information contained in school textbooks, since you now have access to very large sources of data on CD-ROMs or via the internet. You can use this information as background material to be employed in lessons or for pupils to research science topics.

9.3 WHAT ARE THE ARGUMENTS FOR USING ICT IN SCIENCE TEACHING?

The most obvious argument, although the least convincing, is that using ICT is a requirement in the NC for science. However, it is the potential of ICT to assist significantly pupils' learning in science that has resulted in its current high profile. The development of pupils' ICT skills is a separate issue, which will not be covered here.

If we start with computer-aided practical work (data logging), then the most significant benefits lie in the immediacy of the presentation of data in a graphical form. Pupils can spend long periods of time collecting and processing data when they might be much better served by analysing and evaluating data. Some of the benefits of data logging are:

- it provides an immediate link between the activity and the result;
- it gives time for the pupils to think and watch rather than being preoccupied by data gathering;
- it makes it possible to start with a qualitative analysis (the conventional approach requires pupils to deal with numbers in order to plot the graph before they can conduct a qualitative analysis);
- seeing the data presented so quickly encourages pupils to ask 'what if ?'questions and consequently to conduct follow-up activities;
- having the graph on the computer screen provides a focus for both pupils and the teacher to discuss the activity and, most importantly, the science behind the activity.

ICT also offers other tools, such as spreadsheets, which enable routine calculations to be performed, freeing pupils to explore relationships between variables or to model systems – for example, those in predator – prey relationships. Simulations, with animated sequences, enable pupils to view dynamic events. With data projectors now coming within the price range of some science departments, the images produced by these simulations, as well as the numerous science-related CD-ROMs, can now be projected, so that the whole class can view them easily. Finally, ICT offers teachers and pupils access to an unprecedented range of science-related information via the World Wide Web. Using presentation software such as PowerPoint, teachers and pupils can present this information in an informative and stimulating way.

These ideas represent some of the potential of ICT, but the need for carefully designed activities with clear and appropriate learning objectives is still important. The use of ICT does not make you a better teacher, but it does provide a powerful set of tools to support and enhance good teaching.

9.4 WHAT PREPARATIONS SHOULD I MAKE WHEN TEACHING WITH ICT?

The most important message is to proceed carefully and slowly when first introducing the use of ICT into your teaching. Perhaps start by demonstrating a simulation as a small element of a lesson or by using temperature sensors for a practical demonstration. Then you will be able gradually to extend your use of ICT, as your personal skills grow and your confidence increases, making it more central to your lessons.

However, no matter how experienced or confident you are with ICT, the same rules apply as with practical work – plan carefully and always try out the activity before the lesson. With ICT you will need to consider the layout of the room, logistics – such as saving and printing – and, most importantly, how you are going to assess the pupils' performance.

9.5 WHERE WILL I FIND USEFUL WEB-BASED RESOURCES?

See Useful reading and resources for this chapter

The problem in identifying websites which might provide useful material is that the internet is changing all the time, and some material is removed or moved to other locations. Therefore, as time goes on, the list of sites identified will become increasingly out of date. However, it is often possible to use one site to locate useful material on other sites. The booklet *Science on-line* published by Becta (2000) includes a useful list of websites and some activities using the World Wide Web. The Association for Science Education (ASE) has recently published a collection of worksheets that make use of the web. The list of web addresses (left) is intended simply to indicate something of the range of materials that is available for use in science education.

www.explorescience.com
www.bbc.co.uk/learning
www.thecatalyst.org
www.teachernet.gov.uk
www.webelements.com
www.cellsalive.com

Useful reading and resources

Adey, M, Shayer, P and Yates, C (2001) *Thinking science (Third Edition).* Cheltenham: Nelson Thornes.

Association for Science Education (1999) *Safe and exciting science.* Hatfield: ASE.

Association for Science Education (1999) *Teaching Secondary biology.* Hatfield: ASE.

Association for Science Education (1999) *Teaching Secondary chemistry.* Hatfield: ASE.

Association for Science Education (1999) *Teaching Secondary physics.* Hatfield: ASE.

Association for Science Education (2000) *Science@web/getting.started.* Hatfield: ASE.

Becta (2000) *Science on-line.* Coventry: Becta.

Birrell, I J (1996) *Insight into biology experiments.* Edinburgh: Data Harvest.

Birrell, I J (1996) *Insight into chemistry experiments.* Edinburgh: Data Harvest.

DfEE (2000) *Sex and relationship education guidance (*ref DfEE 0116/2000). London: DfEE.

Driver, R (1994) 'The fallacy of induction in science teaching' in Levinson, R (ed.) (1994) *Teaching science.* London: Routledge.

Driver, R, Squires, A, Rushworth, P and Wood-Robinson, V (1994) *Making sense of Secondary science. Research into children's ideas.* London: Routledge.

Gunstone, R F (1991) 'Reconstructing theory from practical experience' in B. Woolnough (ed.) (1991) *practical science: The role and reality of practical work in school science.* Buckingham: Open University Press.

Hodson, D and Hodson, J (1998) 'From constructivism to social constructivism: A Vygotskian perspective on teaching and learning science.' *School Science Review, 79,* 288, 33–41.

Jones, A V (1990) *Science education for pupils with Special Educational Needs.* Nottingham: Nottingham Polytechnic.

Osborne, J (1993) 'Alternatives to practical work' in *School Science Review,* 75, 271.

Richardson, I and Goldsmith, S (2001) *Total revision KS3 Science.* London: Collins.

Watt, A (1996) *Insight into physics experiments.* Edinburgh: Data Harvest.

Useful websites

Please note that the websites referred to throughout the chapter have not been reproduced here. At the time of publication, the DfES is in the process of changing the stem of some of its website addresses from *www.dfee* to *www.dfes*. Should you be unsuccessful in making a connection with the address we have provided here, try typing in the alternative stem followed by the rest of the address. You may need Adobe Acrobat Reader™ to view/download any documents available on these websites.

www.bshs.org.uk The British Society for the History of Science (BSHS).